THE

PRODUCTION OF CLEAN MILK

KHAKI UNIVERSITY OF CANADA

Series 1.—No. 7.

1918

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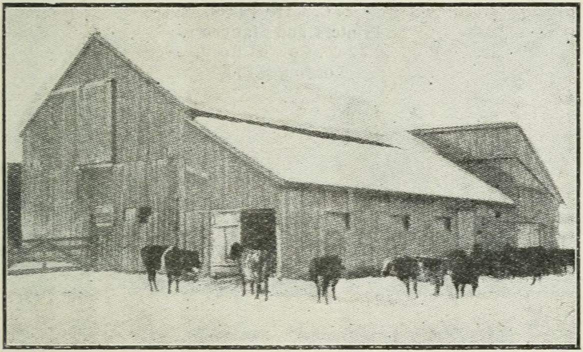

FIG. 63. — *An inexpensive barn, but one in which clean milk is produced by means of careful attention to methods.*

Reprinted, with adaptations, from "THE PRODUCTION OF CLEAN MILK," *by T. J. McInerney, in "Cornell Reading Courses."*

J. C. KING, Ltd.,
Printers and Stationers,
42-60, Goswell Road,
London, E.C. 1.

THE PRODUCTION OF CLEAN MILK

T. J. McInerney

We present herewith, as a basis for the discussion of this topic, the score card used in enforcing the Milk Ordinance, passed in New York on January 1st, 1915.

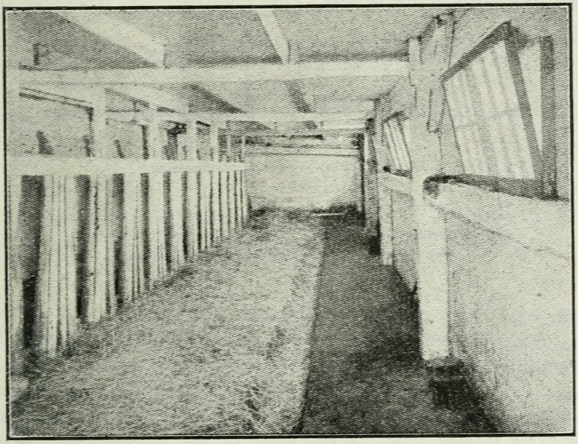

Fig. 64.—*Interior of barn shown in Fig. 63.*

This score card (pages 5 to 7) attempts to enumerate the points that a good dairy should possess, and gives these points a numerical value. This card may be copied and used in scoring the reader's dairy. Probably

the dairy score card is most valuable in an educational way. It is educational to the farmer or dairyman because it points out certain defects and shows wherein he can improve; it is educational to the consumer because he can see which dairies are best from a sanitary standpoint. The score card is divided into two parts, equipment and methods. The equipment is given a value of 40 per cent. and the methods 60 per cent. The reason for this difference is that a man may have a poor dairy barn, that is, a poor equipment as to buildings and the like, but if he is neat and clean in his methods he

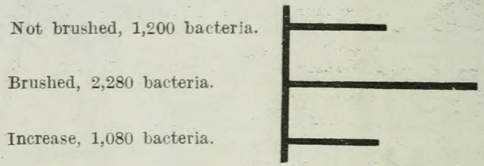

FIG. 65. — *A diagram showing the increase in the bacteria content of milk caused by brushing the cows immediately before milking.*

can produce a good grade of milk and receive credit for his clean methods on the score card. In Figs. 63 and 64 are shown the exterior and the interior of an inexpensive barn. By careful attention to methods, milk was produced in this barn that had an average for one year of 5133 bacteria per cubic centimetre in morning's milk and 5,000 bacteria per cubic centimetre in night's milk.

Because a man may have an excellent or a very expensive dairy farm, it does not follow that a good grade of milk is produced. If the methods are unclean, the milk will be of an inferior quality, and the score will be reduced under methods.

SCORE CARD USED IN ENFORCING THE MILK ORDINANCE.

Indorsed by the Official Dairy Instructors' Association.

Owner or lessee of farm..

P. O. Address................................State................

Total number of cows....................Number milking............

Gallons of milk produced daily.....................................

Product is sold by producer to families, hotels, restaurants, stores, or to...dealer

For milk supply of...

Permit No. .... Date of inspection......................19...

REMARKS..

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(*Signed*)...

Inspector.

SCORE

Equipment.	Score.	
	Perfect.	Allowed
Cows.		
Health—Apparently in good health, 1; if tested with tuberculin within a year and no tuberculosis is found, or if tested within six months and all reacting animals removed, 5. (If tested within a year and reacting animals are found and removed, 3.)	6	....
Food, clean and wholesome........................	1	....
Water, clean and fresh...........................	1	....
Stables.		
Location of stable—Well drained, 1; free from contaminating surroundings, 1......................	2	....
Construction of stable—Tight, sound floor and proper gutter, 2; smooth, tight walls and ceiling, 1; proper stall, tie, and manger, 1..................	4	....
Provision for light: 4 sq. ft. of glass per cow (3 sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1. Deduct for uneven distribution)........................	4	....
Bedding..	1	....
Ventilation—Provision for fresh air, controllable flue system, 3. (Windows hinged at bottom, 1.50; sliding windows, 1; other openings, .50.) Cubic feet of space per cow, 500 ft., 3. (Less than 500 ft., 2; less than 400 ft., 1; less than 300 ft., 0.) Provision for controlling temperature, 1..............	7	....
Utensils.		
Construction and condition of utensils..............	1	....
Water for cleaning (clean, convenient and abundant)	1	....
Small-top milk pail..............................	5	....
Milk cooler......................................	1	....
Clean milking suits..............................	1	....
Milk-room or Milk-house.		
Location free from contaminating surroundings......	1	....
Construction of milk-room—Floor, walls and ceiling, 1; light, ventilation, screens, 1..............	2	....
Separate rooms for washing utensils and handling milk..	1	....
Facilities for steam (hot water, 0.5)................	1	....
Total..	40	....

Methods.	Score.	
	Perfect.	Allowed.
Cows.		
Clean (free from visible dirt, 6)......................	8	....
Stable.		
Cleanliness of stable—Floor, 2 ; walls, 1 ; ceiling and ledges, 1 ; mangers and partitions, 1 ; windows, 1	6	....
Stable air at milking time—Freedom from dust, 3 ; freedom from odours, 2..........................	5	....
Cleanliness of bedding............................	1	....
Barnyard—Clean, 1 ; well drained, 1...............	2	....
Removal of manure daily (to 50 ft. or more from stable)..	2	....
Milk-room or Milk-house.		
Cleanliness of milk-room..........................	3	....
Utensils and Milking		
Care and cleanliness of utensils — Thoroughly washed, 2 ; sterilised in steam for 15 minutes, 3. (Placed over steam jet or scalded with boiling water, 2.) Protected from contamination, 3.......	8	....
Cleanliness of milking—Clean, dry hands, 3 ; udders washed and wiped, 6..........................	9	....
(Udders cleaned with moist cloth, 4 ; cleaned with dry cloth or brush at least 15 minutes before milking, 1.)		
Handling the Milk.		
Cleanliness of attendants in milk-room..............	2	....
Milk removed immediately from stable without pouring from pail..............................	2	....
Cooled immediately after milking each cow..........	2	....
Cooled below 50° F. (51° to 55°, 4 ; 56° to 60°, 2)..	5	....
Stored below 50° F. (51° to 55°, 2 ; 56° to 60°, 1)....	3	....
Transportation below 50° F. (51° to 55°, 1.50 ; 56° 60°, 1)..	2	....
(If delivered twice a day, allow perfect score for storage and transportation.)		
Total................................	60	....

Equipment............ + Methods.......... =........Final Score..

Note 1.—If any exceptionally filthy condition is found, particularly dirty utensils, the total score may be further limited.

Note 2.—If the water is exposed to dangerous contamination, or if there is evidence of the presence of a dangerous disease in animals or attendants, the score shall be 0.

First of all in the production of clean milk, it is necessary to have healthy cows. If the cows are diseased, their milk may contain disease-producing bacteria or be otherwise unfit for use. Special attention should be given to the condition of the udder, and any milk that appears slimy, ropy, watery, coloured, or otherwise abnormal should be discarded. A skilled veterinarian may do much to determine the general health of a cow by giving her a thorough physical examination. Clean and wholesome food, as well as plenty of clean fresh water, are essential. If the watering trough and surroundings are kept clean, there is less chance of the water supply being contaminated.

The surface of the cow's body is one of the most important sources of milk contamination. It is therefore essential that extra care be given to keep the cow clean. Cows kept on pasture usually keep cleaner than those kept in the barn, but in either case thorough grooming is necessary to remove loose hairs, dust, micro-organisms, and the like, so that they will not fall into the milk pail. The process of grooming, feeding or bedding the cows tends to fill the air with dust and bacteria ; therefore these operations should be done long enough before milking to give the dust plenty of time to settle. The increase in the bacteria count in milk drawn shortly after grooming and feeding is shown in Figs. 65 and 66. The data used in the construction of these diagrams were taken from experiments conducted at the Connecticut (Storrs) Agricultural Experiment Station.*

* "Quality of Milk Affected by Common Dairy Practices." By W. A. Stocking, jun. Connecticut (Storrs) Agricultural Experiment Station. Bulletin 42.

A damp cloth used on the cow's udder and flanks just before milking will remove most of the dust and loose

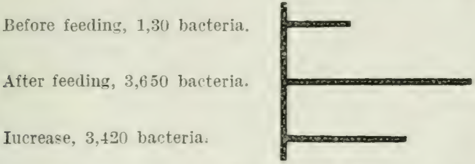

FIG. 66. — *A diagram showing the increase in the bacteria content of milk caused by feeding the cows dry corn stover immediately before milking.*

hairs that might otherwise fall into the milk pail. This will reduce the bacteria count, as is shown in Fig. 67.

THE STABLE.

High ground sloping toward the south or the east is an ideal site for a barnyard in this State, for a slope in either of these directions protects the animals from the

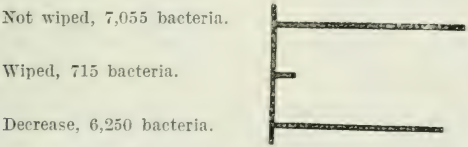

FIG. 67. — *A diagram showing the decrease in the bacteria content of milk caused by wiping the cows' udders with a damp cloth immediately before milking.*

prevailing winter winds. Pig-pens, outhouses, piles of manure, and the like, left standing in the barnyard, may be sources of contamination.

The construction of the stable may be of less importance than careful methods in the production of clean milk, but it should be such as to lighten the labour necessary for keeping the stable and its equipment clean. The most common defect in dairy stables is a lack of cleanliness. The interior of the barn should be so constructed that dirt, cobwebs, and the like, cannot easily collect. The stable floor and the gutter should be made of some material, such as cement, that will not absorb moisture, but that is easy to clean and disinfect in case of necessity. A swing stanchion is more comfortable for a cow than a rigid one, and should be so constructed that it does not collect dirt. The length of the stalls should be such that the cows can stand comfortably and the droppings fall into the gutter. A sufficient amount of clean bedding should be used to insure the comfort and the cleanliness of the cows.

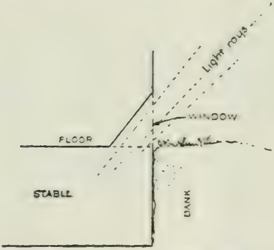

FIG. 68. — *A diagram showing a method of lighting a basement stable.*

Another requirement of a sanitary cow stable is good light, which is necessary in order that the work may be properly done and that the general health of the animals may be good. A good coat of whitewash applied to the interior of the stable at least twice a year is a very inexpensive and efficient method of keeping it light and clean; a bright, clean stable is a great incentive to the production of clean milk. Sunlight is one of our greatest natural disinfectants, and the stable should have plenty of window space so that the sunlight can enter. If light is

lacking on the underground side of a basement stable, a window may be cut in the floor above according to the diagram shown in Fig. 68.

Good ventilation, as well as plenty of sunlight, is necessary for the health of the animals. Every dairy stable should have some system of ventilation to keep the air fresh and pure and the cows comfortable and unexposed to injurious draughts. Poor ventilation usually means poor sanitary conditions. One good method of

FIG. 69. — *Types of sanitary milk pails.*

ventilation is the King system, but this will not work unless the building is tight. Simple direct openings are very effective, but they are likely to make a direct draught, especially if they are exactly opposite each other. The cloth curtain system has two advantages in that it is inexpensive and the curtains can be easily replaced when they become dirty, but the main disadvantages are that this system may collect dust and may not be suitable for cold climates.

THE CONSTRUCTION AND THE CARE OF DAIRY UTENSILS.

Probably no one thing will have a more beneficial effect on the production of clean milk than the use of a small top, or a covered, milk pail (Fig. 70). There seems to be a prejudice on the part of many dairymen against this type of pail, based on the ground that it is difficult to use. Perhaps a part of this prejudice is due to the fact that some impractical pails have been put on the market. There are, however, many good types of sanitary pails (Fig. 69), and careful inquiry has shown that not a single dairyman who has given this type of pail a fair trial would go back to using the old wide-mouth type. A pail that is about two-thirds or three-fourths covered is the type that is in general use.

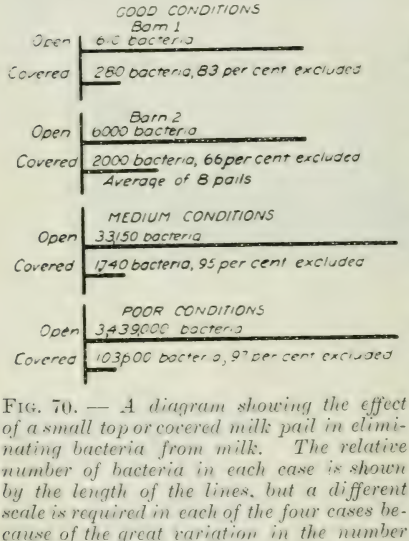

FIG. 70. — *A diagram showing the effect of a small top or covered milk pail in eliminating bacteria from milk. The relative number of bacteria in each case is shown by the length of the lines, but a different scale is required in each of the four cases because of the great variation in the number of bacteria, as shown by the figures.*

All dairy utensils should be so constructed that they can be easily cleaned. This means that all crevices and seems of the utensils must be well flushed with solder

(Fig. 71). If the seams and crevices are left open, as in diagram *A*, milk will accumulate in these places: it is practically impossible to thoroughly wash and sterilize such utensils. This deposit of partly decomposed milk forms an excellent breeding place for bacteria, which contaminate each fresh lot of milk put into the utensil. This contamination may be so great as to very seriously affect the keeping quality of the milk.

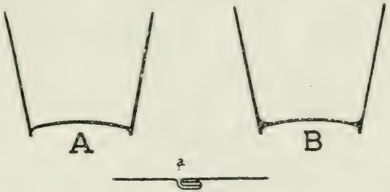

Fig. 71. — *A diagram showing the wrong and the right kinds of a milk pail.* A *shows the ordinary type, which has a sharp angle between the sides and the bottom;* B *shows the same pail properly flushed with solder, so as to facilitate thorough cleaning. The lower figure represents a joint as ordinarily made in tinware. The depression* (a) *affords a place of refuge for bacteria, from which they are not readily dislodged. This joint should be filled completely with solder.*

The proper procedure in cleaning any dairy utensil is as follows: First, rinse the utensil in lukewarm water; second, wash it thoroughly with a brush in a strong solution of hot water and washing powder, about a handful to a 12- or 14-quart pail of water; third, scald it with boiling water or place it in a steam sterilizer. The reason for each step in the procedure is as follows: Lukewarm water is used for rinsing the utensil because milk contains about .7 of 1 per cent. of albumen, which is coagulated and precipitated on the utensil so that it is very hard to remove if water of a temperature of 160° F. or above is used. The utensil should be washed in a strong solution

of alkali powder and hot water because normal milk contains about 4 per cent. of milk-fat, and this solution will dissolve any fat that is on the utensil. A brush is best to use for this work because it enters the seams and crevices better and can be kept clean much more easily than a cloth, which may be a breeding place for bacteria unless great care is given to cleaning it each time after using. The utensil must be sterilized in order to be perfectly clean. If water is used for this purpose, it must have a temperature of 180° F. or higher in order to kill all bacteria that may be present. The utensil should be left in this water for at least several minutes in order to become sterile.

The value of thorough sterilizing of utensils is shown by the following results of bacteriological tests of milk samples taken from dairies where the utensils were properly scalded and where they were not scalded. All these samples were taken on the same days as the producers delivered the milk to the dealer. A's utensils were properly washed and scalded twice a day, but B's were not scalded.

Date of taking sample.	Bacteria per cubic centimetre in A's milk.	Bacteria per cubic centimetre in B's milk.
1913.		
November 1	2,000	98,000
1914.		
January 20	2,500	141,000
January 30	6,000	4,697,000
March 14	19,000	54,000
March 28	50,000	5,400,000
April 11	2,500	600,000
April 20	3,000	680,000
May 28	3,500	172,500
May 25	7,000	965,000
June 1	6,000	6,750,000
June 9	23,000	1,600,000
June 18	9,500	1,200,000
June 26	9,000	600,000
Average	11,000	1,765,961

The figures in the preceding table show the very important part the sterilization of utensils plays in the production of clean milk.

On the official dairy score card, the two dairies showed the following score :—

	Equipment	+	Methods	=	Final Score.
A =	29.3	+	48.1	=	77.4
B =	28.0	+	37.2	=	65.2

The equipment in B's case was about the same as in A's, but the methods in A's case were nearly 11 per cent. better; methods and not equipment count most in the production of clean milk.

THE MILK ROOM OR THE MILK HOUSE.

The location and the construction of the room or the house in which the milk is handled and the utensils washed is also a very important factor in clean milk production. The milk house should be so located that it will have good drainage and be free from any contamination. The principal purpose in building a milk house is to provide a place where the milk and the utensils may be handled apart from all other dairy operations.

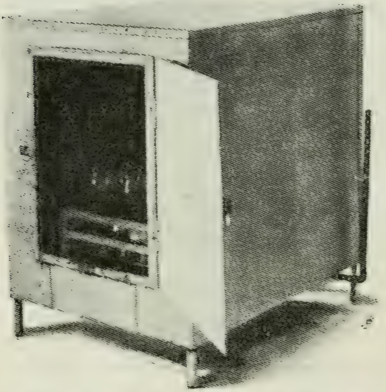

FIG. 72. — *A galvanized iron sterilizer. This is inexpensive and saves labour.*

The milk room or milk house should be so constructed and cared for that it will be thoroughly clean. Smooth, tight walls and ceilings are desirable for the same reason here as in the dairy barn, that is, they prevent the collection of dirt. Milk house floors made of cement are more sanitary and durable than wood floors, because

they do not readily absorb moisture, are more easily cleaned, and are not injured by water used in cleaning the utensils and the floor itself. The milk house should be well supplied with fresh air and sunlight, and special care should be taken to have the air free from odours. It is a well-known fact that milk will readily take up odours, and, for this reason if no other, a clean milk house is necessary if the milk is to be properly handled. Flies and other insects may be kept out of the milk house by having the doors and the windows properly screened. A good supply of fresh water is one of the requirements of a well-equipped milk house.

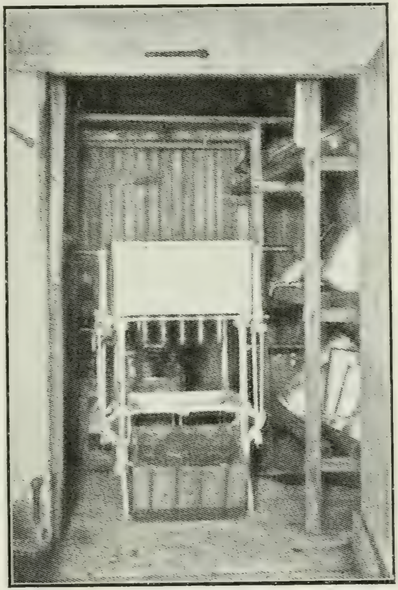

FIG. 73. — *A stationary sterilizer constructed of concrete and hollow tile. The racks and doors are of wood.*

The milk room should be provided with facilities for heating a liberal supply of water for washing and steri-

lizing the utensils. This may be done on a stove or by turning steam into a half barrel. Either boiling water or steam will do efficient sterilizing if properly used. If a supply of steam can be had, the sterilizing process can be simplified by placing all of the utensils in a sterilizer, where they are all treated at one time with less labour than is necessary to thoroughly scald each piece with boiling water. There are several forms of good, efficient sterilizers on the market of the general type shown in Fig. 72. All of the utensils used during the entire day can be sterilized at one time in one of these machines. Larger forms of stationary sterilizers can be built of concrete or hollow tile, as shown in Fig. 73. If a steam sterilizer is used, the utensils will be dried by their own heat if the steam is allowed to escape immediately after the heating period. The door can then be closed, and the utensils are thus protected from contamination until ready for use. The length of time necessary to sterilize the utensils, or to heat the sterilizer and its contents to the temperature of the steam, should be determined. In the small iron sterilizers, this requires only a few minutes, while in the large concrete or tile sterilizers, it may require from twenty to thirty minutes.

COOLING MILK.

H. E. Ross and T. J. McInerney.

Bacteria and their products are the cause of unwholesome milk. These small plants are present nearly everywhere, and some of the commonest sources from which they enter milk are the dust in the air, the body of the cow, the person of the milker, and dirty utensils.

Like other plants, bacteria require certain cond tions for their growth, one of the most important being a favourable temperature. Most germs thrive best at a temperature of about 98° F., or 36.6° C., and this is very nearly the temperature of freshly drawn milk. Milk should be cooled to at least 50° F. as soon as possible after it is drawn; it is still better to cool it to a temperature as low as 40° F. While it is true that many of the bacteria that are commonly found in milk either do not develop at all, or at least develop very slowly at 50° F., still there are some forms that grow with comparative rapidity at this temperature. For this reason the colder the milk is kept, the better it will be, provided it is not frozen.

TABLE 1.—COMPARISON OF BACTERIA COUNT OF SAMPLES OF MILK HELD AT DIFFERENT TEMPERATURES FOR ONE HOUR.

Sample.	Number of pounds milk used.	Bacteria per c.c. in original milk.	Bacteria per c.c. in milk held at 50° F.	Bacteria per c.c. in milk held at 90° F.	Increase in bacteria per c.c. of milk held at 90° F. over milk held at 50° F.
1.......	40	747,750	727,750	2,499,500	1,771,750
2.......	43	308,900	566,250	1,487,750	921,500
3.......	72	537,500	420,000	7,625,000	7,205,000
4.......	85	575,000	470,000	6,000,000	5,530,000
5.......	85	179,375	158,125	4,920,000	4,761,875
6.......	85	223,125	282,500	760,000	477,500
7.......	80	31,875	65,000	1,675,000	102,500
8.......	64	47,750	110,000	355,000	245,000
9.......	85	20,625	29,375	37,000	7,625
10......	75	86,875	141,875	1,350,000	1,208,125

A comparison of the bacteria count of various samples of milk is given in Table 1. Each sample was divided into two parts, and one part was held at a temperature of 50° F. for one hour, the other at 90° F. for the same time. In each case the samples were thoroughly mixed by pouring the milk several times from one can to another, before they were held at their respective temperatures for the period stated. The table indicates that there was a large increase of bacteria, due to keeping milk at the higher temperature, and also that those samples of milk that had a high initial bacteria count had a correspondingly high count at the end of an hour. This point is of great practical importance, and shows the necessity of producing clean milk even though it is to be kept cold or is to be pasteurised. If conditions favourable to the growth of bacteria arise, a large initial count means that the bacteria have a proportionately better chance to multiply.

It is interesting to note that in four of the ten tests here recorded, the bacteria count of the milk, after it had been held for one hour at 50° F., was less than the initial bacteria count. This is probably due to the fact that the low temperature was unfavourable to the particular species of germs that happened to be present.

TABLE 2.—EFFECT OF HIGH TEMPERATURE ON MILK HAVING A SMALL INITIAL BACTERIA COUNT.

Sample.	Number of pounds milk used.	Temperature (° F.) at which milk was held for 2 hours.	Number of bacteria per c.c.		Increase of bacteria per c.c.	
			At beginning of the 2-hours period.	At end of 2-hours period.	Number	Percentage.
1.............	80	85°	560	4,000	3,440	614.2
2.............	80	89°	2,862	6,335	3,473	121.3
3.............	86	80°	2,967	15,925	13,958	470.4
3.............	86	85°	2,612	24,450	21,838	836.0
5.............	50	85°	3,062	64,700	61,638	2,012.9
6.............	50	85°	362	2,025	1,663	459.3
7.............	60	88°	2,675	28,662	25,987	971.4
8.............	70	84°	500	9,800	9,300	1,860.0

The importance of cooling milk and of keeping it cold is still further emphasised in Table 2, which sets forth the results of keeping at a high temperature milk that had a low initial bacteria count. In each case the milk was held at a high temperature for a period of two hours, and it will be noted that in every case there was a large increase in germ content.

The place where the milk is cooled must be clean and free from dust. Bacteria are carried on dust particles, which float about in the air ; therefore the handling of hay or grain at the time and the place that milk is being cooled is a bad practice because the dust from both of these feeds is loaded with germs. Furthermore, milk takes up odours very readily, and for this reason should be cooled in a place free from odours of any kind. Straining and cooling milk directly behind the

cows is a particularly bad practice. The odours from stable manure, and oftentimes from silage, are thus transmitted to milk.

If milk is cooled slowly, many germs may develop during the process, although a low temperature may be reached ultimately. If germs should develop thus, and if conditions should again become favourable for the growth of bacteria, the milk would soon spoil.

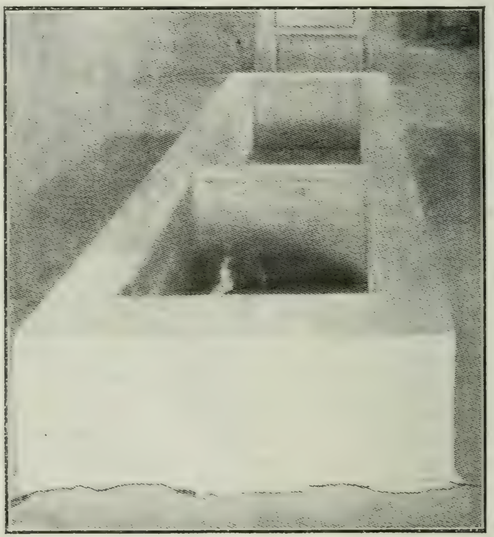

FIG. 74.—*A cement tank for cooling milk.*

The walls extending above the level of the floor prevent dirt from washing into the tank.

METHODS OF COOLING MILK.

Milk becomes cool, of course, when it gives up its heat to some substance colder than itself, and in order to have a rapid exchange of temperatures between two substances it is necessary that they have approximately the same density. On account of the great difference in density between air and milk, the latter will cool very slowly in air even though the temperature of the air is rather low. If milk is allowed to cool by standing in a cold atmosphere, it will do so unevenly, and by the time the milk in the centre of the can is cooled, that part near the walls of the can may be frozen.

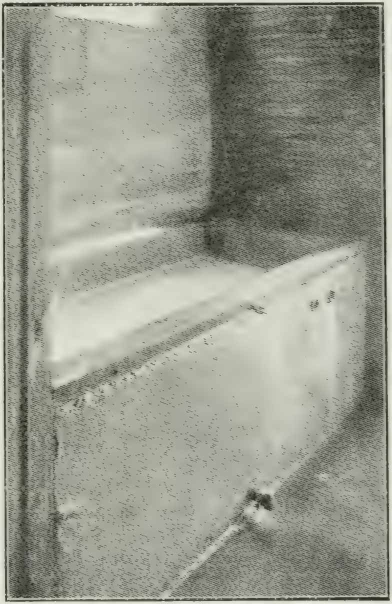

FIG. 75.— *A cement tank for cooling milk.*

The top of the wall is faced with iron to protect the wall from chipping.

The fat is not evenly distributed in frozen milk, therefore it is not so good as normal milk.

TANKS.

On farms, milk is most often cooled by setting the cans containing it in a tank of water. The most convenient and in the long run the cheapest kind of tank for this purpose is made of cement and sunk in the floor so that only about twelve inches of the sides extend above it. This arrangement obviates lifting the cans to any great height, and prevents dirt from washing into the tank. The top of the walls of the tank should be faced with strap iron to prevent the cans cracking the cement as they are lifted in and out. Some outlet should be provided in the bottom of the tank so that it can be easily and thoroughly cleaned as often as may be necessary. It is almost impossible to prevent milk from spilling into a cooling tank of this sort, and unless this is cleaned out the tank soon becomes unfit for use from a sanitary standpoint. Outlets should be made at the top of the tank in order to carry off surplus water and to prevent the cans from being flooded.

Another type of cooling tank is made of galvanized iron faced with iron at the top and the bottom. Such a tank is not so serviceable as one made of cement, but it is more durable than a wooden one and is easier to keep clean (Fig. 76). A galvanized iron tank large enough for cooling four or five cans of milk may be bought for from eight to ten dollars.

In size the tank should be large enough to hold the required number of cans and to allow about three inches between each can and about four inches between the cans and the walls of the tank. The larger the tank,

the greater is the amount of ice needed to cool the water around the cans; therefore the tank should be

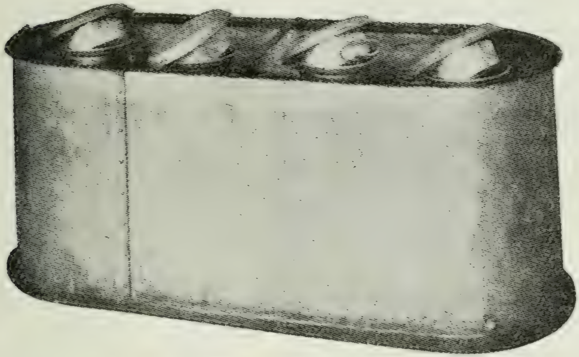

FIG. 76.—*Metal tank for cooling milk.*

no larger than necessary. It must, of course, be deep enough to allow the water to rise around the necks of the cans.

Refrigerating Material.

The refrigerating material most commonly used in cooling milk in tanks is cold water or ice water. It is generally necessary to use ice, since few wells or springs furnish water sufficiently cold to cool milk to the proper temperatures. The amount of ice necessary can best be determined by experiments because it varies with the amount of milk to be cooled, the temperature of the surrounding atmosphere, and the temperature of the water in which the ice is placed.

Effect of Stirring Milk during Cooling in Tanks.

The cooling process, in order to be thorough, requires more than setting the can of milk in a tank of ice water ; the milk must be stirred frequently. If the milk is not stirred, that which is near the walls of the can will become cold, while that in the centre of the can will for a long time maintain a high temperature favourable to the growth of bacteria. Results showing the rate of cooling when milk was and was not stirred during the cooling process are given in Table 3. In each experiment in Table 3 can 1 was stirred at intervals of five minutes, and the temperature recorded ; can 2 was stirred at intervals of ten minutes and the temperature recorded ; can 3 was not stirred at all, but the temperature of the milk in the centre of the can was recorded at intervals of ten minutes ; can 4 was stirred continuously, and the temperature recorded at intervals of ten minutes.

In each experiment, with the exception of one, recorded in Table 3, the milk in can 4, which was stirred continuously, registered the lowest temperature at the end of an hour ; while the milk in cans 1 and 2, which was stirred every five minutes and every ten minutes respectively, registered about the same final temperature, but not so low as that obtained in can 4. The milk in can 3, which was not stirred at all during the hour, had a higher temperature than that in the three other cans. This was due to the fact that the milk in the centre of the can was not near enough to the cooling mixture ; however, when the milk in this can was stirred at the end of the hour, the mixed milk had a temperature that compared very favourably with that of the milk in cans 1 and 2. This would indicate that the milk near the walls of the can had a low temperature.

TABLE 3.—EFFECT OF STIRRING MILK AT DIFFERENT INTERVALS OF TIME ON RAPIDITY OF COOLING.

Experiment.	Can.	Number of pounds ice used.	Temperature of milk (degrees Fahrenheit) at												
			9.00 a.m.	9.05 a.m.	9.10 a.m.	9.15 a.m.	9.20 a.m.	9.25 a.m.	9.30 a.m.	9.35 a.m.	9.40 a.m.	9.45 a.m.	9.50 a.m.	9.55 a.m.	10.00 a.m.
1.	1	322	95°	77°	70°	65°	60°	57°	55°	52°	51°	49°	48°	47°	45°
	2	322	95°	—	73°	—	62°	—	56°	—	52°	—	48°	—	46°
	3	322	95°	—	85°	—	78°	—	70°	—	69°	—	63°	—	61°
	4	322	95°	—	64°	—	54°	—	47°	—	43°	—	41°	—	39°
2.	1	323	95°	86°	78°	74°	71°	69°	65°	63°	61°	60°	58°	57°	54°
	2	323	95°	—	80°	—	72°	—	65°	—	62°	—	59°	—	55°
	3	323	95°	—	90°	—	83°	—	81°	—	76°	—	73°	—	72°
	4	323	95°	—	75°	—	68°	—	63°	—	60°	—	56°	—	54°
3.	1	225	87°	80°	75°	71°	65°	64°	62°	60°	58°	56°	55°	54°	53°
	2	225	87°	—	75°	—	66°	—	63°	—	59°	—	57°	—	53°
	3	225	88°	—	85°	—	77°	—	73°	—	70°	—	68°	—	67°
	4	225	88°	—	70°	—	60°	—	54°	—	51°	—	49°	—	47°
4.	1	140	95°	85°	79°	74°	71°	69°	66°	64°	62°	61°	59°	58°	57°
	2	140	95°	—	80°	—	72°	—	67°	—	63°	—	60°	—	58°
	3	140	95°	—	90°	—	82°	—	75°	—	70°	—	68°	—	63°
	4	140	95°	—	74°	—	63°	—	59°	—	56°	—	54°	—	53°
5.	1	360	95°	83°	75°	70°	66°	63°	60°	57°	55°	54°	52°	50°	48°
	2	360	95°	—	75°	—	67°	—	61°	—	56°	—	53°	—	49°
	3	360	95°	—	88°	—	79°	—	72°	—	65°	—	61°	—	57°
	4	360	95°	—	73°	—	58°	—	51°	—	46°	—	43°	—	41°

TABLE 3 (*continued*).

Experiment.	Can.	Number of pounds ice used.	Temperature of milk (degrees Fahrenheit) at												
			9.00 a.m.	9.05 a.m.	9.10 a.m.	9.15 a.m.	9.20 a.m.	9.25 a.m.	9.30 a.m.	9.35 a.m.	9.40 a.m.	9.45 a.m.	9.50 a.m.	9.55 a.m.	10.00 a.m.
6.	1	293	93°	80°	72°	69°	63°	62°	61°	58°	56°	55°	51°	53°	52°
	2	291	93°	—	73°	—	64°	—	61°	—	56°	—	54°	—	52°
	3	293	93°	—	84°	—	76°	—	70°	—	64°	—	60°	—	56°
	4	293	93°	—	69°	—	57°	—	52°	—	48°	—	46°	—	43°
7.	1	125	96°	90°	81°	76°	71°	68°	65°	62°	59°	58°	56°	55°	53°
	2	125	96°	—	80°	—	72°	—	71°	—	59°	—	56°	—	58°
	3	125	96°	—	92°	—	80°	—	71°	—	67°	—	63°	—	58°
	4	125	96°	—	73°	—	61°	—	53°	—	49°	—	46°	—	44°
8.	1	200	95°	86°	80°	76°	71°	68°	66°	63°	61°	59°	58°	56	55°
	2	200	95°	—	80°	—	70°	—	66°	—	61°	—	58°	—	55°
	3	200	95°	—	92°	—	83°	—	73°	—	69°	—	64°	—	59°
	4	200	95°	—	71°	—	60°	—	55°	—	50°	—	48°	—	46°
9.	1	200	95°	88°	82°	76°	71°	68°	65°	64°	61°	59°	57°	56°	55°
	2	200	95°	—	82°	—	71°	—	66°	—	61°	—	57°	—	55°
	3	200	95°	—	90°	—	80°	—	72°	—	67°	—	63°	—	58°
	4	200	95°	—	71°	—	59°	—	54°	—	51°	—	48°	—	46°
10.	1	200	95°	85°	78°	75°	69°	68°	65°	63°	60°	59°	57°	56°	54°
	2	200	95°	—	78°	—	70°	—	65°	—	60°	—	57°	—	54°
	3	200	95°	—	91°	—	82°	—	76°	—	66°	—	62°	—	61°
	4	200	95°	—	64°	—	53°	—	48°	—	44°	—	42°	—	40°

TABLE 4.—COMPARISON OF TEMPERATURE OF MILK IN CENTRE OF CAN AT END OF COOLING PERIOD BEFORE STIRRING AND AFTER STIRRING.

Sample.	Temperature of milk (° F.) in centre of can.	
	Before stirring.	After stirring.
1	66°	49°
2	73°	57°
3	68°	61°
4	61°	58°
5	72°	53°
6	70°	56°
7	60°	54°
8	68°	54°
9	64°	52°
10	62°	56°

Stirring milk during cooling produces a rapid drop in temperature, which is advantageous because it checks the growth of bacteria. They develop more slowly, as has been stated, as the temperature of the milk decreases.

In each experiment recorded in Table 3, all the milk in can 4—which was stirred continuously—was cooled very rapidly, and the largest drops in temperature

occurred near the beginning of the period; while in can 3, which was not stirred at all, the temperature of the milk ranged as high as 72° F. at the end of the hour. The point is further illustrated in Table 5, according to which at the end of twenty minutes the difference in temperature due to stirring the milk varied from 3° to 17° F., and the average difference in temperature between the milk stirred and not stirred was 9.7° F. This average drop in temperature, 9.7° F., in twenty minutes due to stirring means an effective check on the development of bacteria. For all practical purposes it seems that stirring the contents of the can once every ten minutes for an hour is sufficient.

TABLE 5.—EFFECT OF STIRRING MILK ON RAPIDITY OF COOLING.

Can.	Stirred at intervals of 10 minutes.		Not stirred.		Difference in temperature (° F.) due to stirring.
	Temperature of milk (° F.) at		Temperature of milk (° F.) at		
	Beginning of experiment.	End of 20 minutes.	Beginning of experiment.	End of 20 minutes.	
1	95°	68°	95°	75°	7°
2	95°	73°	95°	85°	12°
3	90°	75°	92°	80°	5°
4	96°	73°	96°	79°	6°
5	98°	71°	98°	88°	17°
6	95°	69°	95°	78°	9°
7	98°	73°	98°	76°	3°
8	98°	73°	98°	88°	15°
9	96°	72°	98°	86°	14°
10	99°	73°	99°	82°	9°

When a sufficient amount of ice and water are used, stirring the water in the tank at frequent intervals has

little, if any, effect on the rapidity with which the milk cools (Table 6). In this experiment the milk was also stirred every ten minutes. The large quantity of ice used in this experiment is accounted for by the fact that the can of milk from which these temperatures were taken was cooled with three others in the same tank.

COOLERS.

The Conical Type.

There are on the market several coolers that are comparatively cheap in price and yet, when properly used, are efficient in cooling milk in farm dairies. These coolers are more or less alike in type of construction and generally consist of a receiving tank so arranged that the milk flows from holes in the bottom of this tank on to a conical surface and is collected in a trough at the bottom, from whence it flows into the can or other utensil placed to receive it (Fig. 10). The refrigerating material, which usually consists of water and ice, is placed inside of the cone-shaped part of the apparatus, and nearly all coolers of this type are so fixed that ice water or brine may be pumped through them continuously. If water and ice are the refrigerating materials used in this type of cooler, it is absolutely necessary to keep them well stirred ; otherwise comparatively little heat will be removed from the milk. The amount of refrigerating material that can be placed inside the cooler is small in proportion to the amount of milk that usually passes over the conical surface. Even if this proportion of ice water to milk were more nearly equal, it would be necessary to keep the water well stirred, because that which was near the surface of the cooler would soon take up enough heat from the milk to render it useless.

TABLE 6.—EFFECT OF STIRRING WATER IN THE TANK ON RAPIDITY OF COOLING MILK, WHEN SUFFICIENT AMOUNT OF ICE IS USED.

Sample.	No. of pounds milk used.	No. of pounds ice used.	Temperature of milk (degrees Fahrenheit) at												
			Beginning of the experiment.	End of first 10 minutes.		End of second 10 minutes.		End of third 10 minutes.		End of fourth 10 minutes.		End of fifth 10 minutes.		End of sixth 10 minutes.	
				Water stirred.	Water not stirred.	Water stirred.	Water not stirred.	Water stirred.	Water not stirred.	Water stirred.	Water not stirred.	Water stirred.	Water not stirred.	Water stirred.	Water not stirred.
1	83	322	95°	68°	73°	63°	62°	57°	56°	53°	52°	50°	48°	48°	46°
2	81	323	95°	82°	80°	73°	72°	67°	65°	62°	62°	58°	59°	55°	55°
3	81	225	92°	81°	75°	75°	66°	69°	63°	64°	59°	63°	57°	60°	53°
4	80	140	96°	83°	80°	73°	72°	65°	67°	62°	63°	59°	60°	57°	58°
5	85	360	98°	80°	75°	71°	67°	64°	61°	60°	56°	58°	53°	55°	49°
6	85	293	95°	82°	73°	69°	64°	64°	61°	60°	56°	56°	54°	55°	52°
7	86	125	98°	80°	80°	73°	72°	67°	71°	60°	59°	56°	56°	54°	58°
8	85	200	98°	84°	80°	73°	70°	67°	66°	62°	61°	59°	58°	54°	55°
9	85	200	98°	85°	82°	72°	71°	64°	66°	58°	61°	54°	57°	52°	55°
10	85	200	99°	83°	78°	73°	70°	67°	65°	62°	60°	58°	57°	56°	54°

The comparative results of cooling milk with a conical cooler in which the water and ice were stirred and were not stirred, are given in Table 7.

TABLE 7.—COMPARATIVE RESULTS OF COOLING MILK WITH A CONICAL COOLER WHEN THE WATER AND ICE WERE STIRRED AND WERE NOT STIRRED.

Sample.	Number of pounds of milk used.	Number of pounds of ice used.	Temperature of milk (° F.) at finish of experiment.		Temperature of water (° F.) at finish of experiment.		Difference in temperature of milk (° F.) due to stirring.
			Water stirred.	Water not stirred.	Water stirred.	Water not stirred.	
1.......	85	26	58°	69°	62°	58°	11°
2.......	83	26	60°	70°	58°	50°	10°
3.......	84	35	50°	61°	43°	40°	11
4.......	86	25	54°	69°	48°	45°	15
5.......	83	20	56°	68°	56°	50°	12
6.......	83	35	51°	68°	51°	42°	17
7.......	82	35	45°	67°	47°	38°	22°
8.......	73	35	50°	66°	50°	60°	16°
9.......	83	35	52°	72°	52°	45°	20°
10.......	81	35	47°	66°	41°	42°	19°
11.......	75	35	46°	66°	41°	41°	20°
12.......	83	35	45°	70°	44°	40°	25
13.......	84	35	53°	70°	50°	40°	17°
14.......	85	30	47°	63°	47°	41°	16°
15.......	83	25	57°	68°	48°	46°	11°
16.......	73	25	49°	66°	49°	47°	17°
17.......	85	25	57°	64°	52°	52°	7°
18.......	84	25	57°	68°	51°	48°	11

Average difference..15.4

The Tubular Type.

Where comparatively large quantities of milk are to be cooled, tubular coolers are generally used (Fig. 78). This type consists of a series of tubes, usually corrugated.

over which the milk flows and through which the refrigerating material is forced. The corrugation increases the surface over which the milk has to flow, and therefore makes the cooler more efficient.


Fig. 77.— *A conical cooler.*

The refrigerating substance should enter the lower part of the cooler and flow out at the top. By this arrangement milk has part of its heat removed by the warmest refrigerating substance, and as the milk flows down over the cooler, it passes over the tubes that contain the coldest substance. In this way the highest efficiency of the refrigerating substance is obtained. Tubular coolers require either a pump or the force of gravity to circulate the cooling material. Small tubular coolers, such as the one shown in Fig. 78, are sometimes used on farms where there is an abundant water supply. When so used the cooler is attached directly to the well pump or to a reservoir situated above the cooler, and the water is then allowed to run to waste after passing through it.

Ice water and brine are the two substances generally used as refrigerating materials. Of these brine is the

more efficient because lower temperatures can be obtained with it than with ice water alone, due to the fact that when ice and salt unite to form a liquid they absorb heat. The temperature obtained depends on the percentage of salt in the solution, the amount of ice used, the temperature of the milk cooled, and the temperature of the atmosphere. The amount of refrigeration that can be supplied by a given amount of ice and salt can be definitely computed, but the other factors mentioned have so great an influence that the theoretical amount is usually only approximate. The theoretical temperatures that would result from solutions containing different percentages of salt in ice water at 32° F. are given in Table 8, which is taken from a publication of the United States Department of Agriculture.*

TABLE 8.—Approximate Temperatures Resulting from the Mixture of Different Percentages of Salt and Ice.

Percentage of Salt in Mixture.	Temperature of Mixture (° F.).
0	32°
5	27°
10	20°
15	11°
20	1.5°
25	—10°

* "The Application of Refrigeration to the Handling of Milk." By John T. Bowen, U.S. Department of Agriculture. Bulletin 98 (new series).

One of the least expensive and at the same time most efficient methods of cooling milk by the use of brine is by means of a brine barrel (Fig. 79). The barrel selected for this purpose should be of good quality, since it gets almost constant use. The salt and ice are mixed in it, and the brine is pumped from the barrel through the cooler and back to the barrel, from which it is pumped again into the cooler. It is necessary to use a brasslined pump, for one of iron would soon be rusted out by the brine. Most of the coolers are constructed of material such as will withstand the action of brine. In this method of cooling milk, ice water can of course be used instead of brine, but the latter is much more efficient. and is comparatively inexpensive. Comparative results obtained by the use of ice water and of brine and ice in a tubular cooler are given in Table 9.

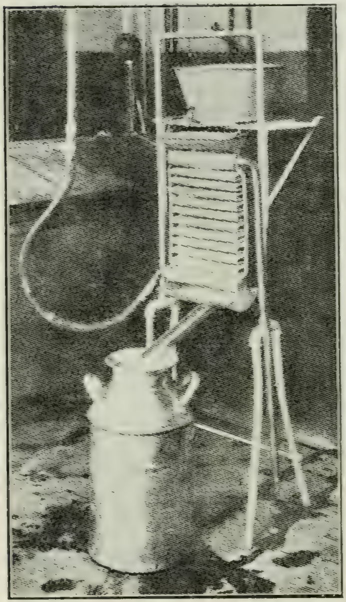

FIG. 78.— *A type of tubular cooler.*

TABLE 9.—COMPARATIVE RESULTS OF COOLING MILK IN A TUBULAR COOLER BY THE USE OF ICE WATER AND OF BRINE AND ICE.

Sample	Number of pounds milk used.	Number of pounds ice used.	Number of pounds salt used.	Temperature of milk (° F.) at beginning of experiment.	Temperature of milk (° F.) at end of experiment.	Difference in temperature of milk (° F.) due to use of brine.	Time required to cool milk (minutes).
1....	250	125	0	90°	47°	6°	9
1a...	250	125	60	90°	41°	—	9
2....	310	125	0	93°	47°	6°	10
2a...	310	125	60	93°	41°	—	10
3....	320	120	0	86°	50°	6°	12
3a...	320	120	60	86°	44°	—	12
4....	320	120	0	96°	49°	3°	12
4a...	320	120	60	96°	46°	—	12
5....	320	120	0	92°	52°	6°	12
5a...	320	120	60	92°	46°	—	12
6....	320	125	0	96°	48°	5.5°	12
6a...	320	125	75	96°	42.5°	—	12
7....	289	125	0	98°	49°	8°	9
7a...	289	125	75	98°	41°	—	9
8....	255	125	0	100°	51°	6°	10
8a...	255	125	75	100°	45°	—	10
9....	172	125	0	95°	48°	4°	7
9a...	172	125	60	95°	44°	—	7
10....	172	125	0	94°	49.5°	9.5°	7
10a...	172	125	60	94°	40°	—	7
Average						6°	

Brine and ice are much more efficient as a refrigerant than is ice water alone, according to the figures in Table 9. In the ten experiments recorded, the milk cooled by brine and ice averaged 6.5° lower than the milk cooled by ice water under the same conditions. These 6.5° are important from the standpoint of checking bacterial growth.

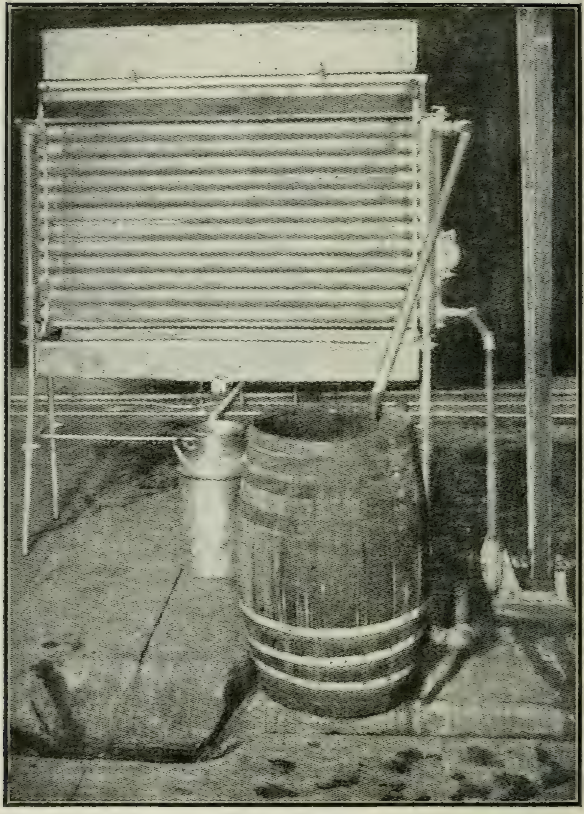

Fig. 79.— *A brine barrel and a type of tubular cooler in which brine may be used as the refrigerating material.*

SUMMARY.

1. The bacteria content of milk held at a temperature of 50° F. increases slowly, while the bacteria content of milk held at 90° F. increases rapidly.

2. At a temperature of 90° F. bacteria increase rapidly in milk that had either a small or a large amount of bacteria in it originally.

3. Cooling milk by placing the cans in a tank of ice water is a practical method for use in farm dairies. To cool the milk rapidly, it must be stirred at frequent intervals (Table 3).

4. Stirring the milk at intervals of five minutes caused a sufficiently rapid drop in temperature. Rapidity of cooling due to stirring the milk at intervals of five minutes and at intervals of ten minutes was very slight (Table 3).

5. When sufficient quantities of ice were used, stirring the water in the cooling tank had little effect on the rapidity of cooling (Table 6).

6. In order to obtain the best efficiency from the conical type of cooler, it is absolutely necessary to stir the water inside the cooler (Table 7).

7. Lower temperatures can be obtained by using brine and ice than with ice water alone (Table 9).

QUESTIONS.

1. From the standpoint of the dairy farmer criticise the score card on equipment and methods, pointing out its good points and bad points.

2. Describe the care and management of the cow in the production of clean, wholesome milk.

3. "Cleanliness" and "coldness" are the dairy farmer's watchwords. Give reasons why this is so.

4. Outline the essentials of a stable for the production of clean milk.

5. Give a list of utensils necessary, and describe their construction and care briefly.

6. How would you wash out a metal vessel in which milk had been kept?

7. Describe the fittings of a convenient milk room.

8. Describe a cement tank and a galvanised iron tank suitable for cooling milk.

9. How does stirring the milk affect its cooling? Describe in detail.

10. Describe the conical cooler, the tubular cooler, and tell how they are operated and the cooling medium used.